ELECTRIC STARTER 5

SPECIFICATIONS 5.1

STARTER	
Free speed	3000 RPM (min.) @ 11.5 V
Free current	90 amp (max.) @ 11.5 V
Stall current	400 amp (max.) @ 2.4 V
Stall torque	8.1 ft-lbs (11.0 Nm) (min.) @ 2.4 V

SERVICE WEAR LIMITS	IN.	MM
Brush length minimum	0.433	11.0
Commutator diameter minimum	1.141	28.981

TORQUE VALUES

ITEM	TORQUE		NOTES
Battery cable bolts **(1999 Models)**	40 **in-lbs**	4.5 Nm	metric, page 5-18
Battery terminal bolts **(2000 Models)**	60-96 **in-lbs**	6.8-10.9 Nm	page 5-18
Starter battery positive cable nut	60-85 **in-lbs**	6.8-9.6 Nm	metric, page 5-18
Starter mounting bolts	13-20 ft-lbs	17.6-27.1 Nm	page 5-18

ELECTRIC STARTER SYSTEM 5.2

GENERAL

The starter is made up of an armature, field winding assembly, solenoid, drive assembly, idler gear and drive housing.

The starter motor torque is increased through gear reduction. The gear reduction consists of the drive pinion on the armature, an idler gear and a clutch gear in the drive housing. The idler gear is supported by rollers. The clutch gear is part of the overrunning clutch/drive assembly.

The overrunning clutch is the part which engages and drives the clutch ring gear. It also prevents the starter from overrunning. The field windings are connected in series with the armature through brushes and commutator segments.

Wiring Diagrams

For additional information concerning the starting system circuit, see the wiring diagram at the end of Section 7, ELECTRICAL.

Starter Relay

The starter relay is not repairable. Replace the unit if it fails.

Starter Interlock

See 7.5 STARTER INTERLOCK for operation and troubleshooting information.

OPERATION

See Figure 5-1. When the starter switch is pushed, the starter relay is activated and battery current flows into the pull-in winding (10) and the hold-in winding (11), to ground.

The magnetic forces of the pull-in and hold-in windings in the solenoid push the plunger (7) causing it to shift to the left. This action engages the pinion gear (1) with the clutch ring gear (13). At the same time, the main solenoid contacts (8) are closed, so battery current flows directly through the field windings (3) to the armature (4) and to ground. Simultaneously, the pull-in winding (10) is shorted.

The current continues flowing through the hold-in winding (11) keeping the main solenoid contacts (8) closed. At this point, the starter begins to crank the engine.

After the engine has started, the pinion gear (1) turns freely on the pinion shaft through the action of the overrunning clutch (12). The overrunning clutch prevents the clutch ring gear (13) (which is now rotating under power from the engine) from turning the armature (4) too fast.

When the starter switch is released, the current of the hold-in winding (11) is fed through the main solenoid contacts (8) and the direction of the current in the pull-in winding (10) is reversed. The solenoid plunger (7) is returned to its original position by the return spring, which causes the pinion gear (1) to disengage from the clutch ring gear (13).

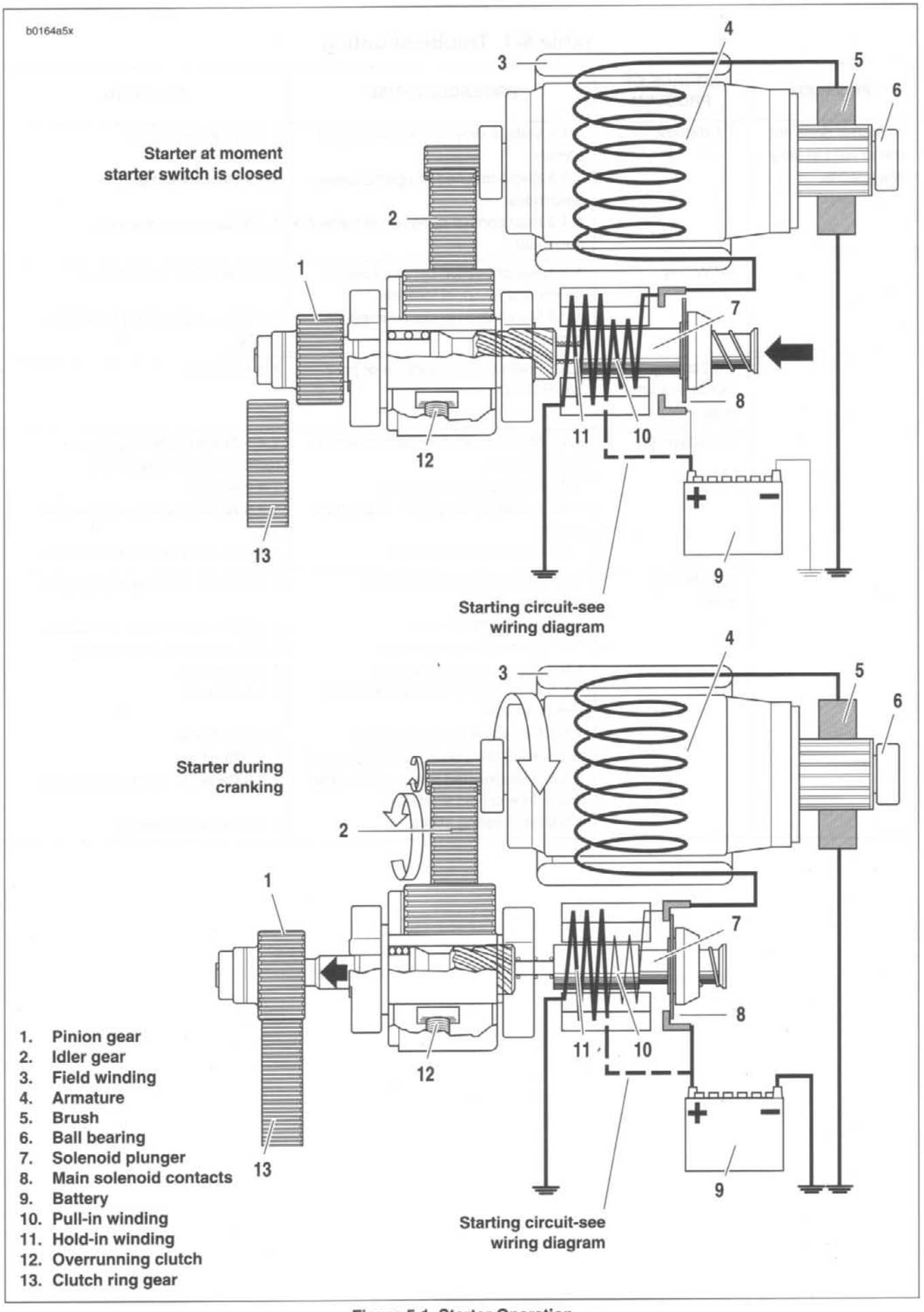


Figure 5-1. Starter Operation

Table 5-1. Troubleshooting

PROBLEM	SOURCE OF PROBLEM	PROBABLE CAUSE	SOLUTION
1. Starter does not run or runs at very low speeds.	1.1 Battery.	1.1.1 Voltage drop due to discharged battery. 1.1.2 Short-circuited or open between electrodes. 1.1.3 Poor contact condition of battery terminal(s).	1.1.1 Charge battery. 1.1.2 Replace battery. 1.1.3 Clean and retighten.
	1.2 Wiring.	1.2.1 Disconnection between starter switch and solenoid terminal. 1.2.2 Malfunction in starter interlock system.	1.2.1 Repair or replace wire. 1.2.2 See 7.5 STARTER INTERLOCK.
	1.3 Starting switch or starter relay.	1.3.1 Poor contact condition or poor connection.	1.3.1 Replace.
	1.4 Solenoid.	1.4.1 Poor contact condition caused by burnt contact. 1.4.2 Contact plate removed. 1.4.3 Pull-in winding open or short-circuited. 1.4.4 Hold-in winding open.	1.4.1 Polish contact surface or replace solenoid assembly. 1.4.2 Repair. 1.4.3 Replace solenoid assembly. 1.4.4 Replace solenoid assembly.
	1.5 Starting motor.	1.5.1 Poor contact condition of brushes. 1.5.2 Commutator burnt. 1.5.3 Commutator high mica. 1.5.4 Field winding grounded. 1.5.5 Armature winding grounded or short-circuited. 1.5.6 Reduction gears damaged. 1.5.7 Insufficient brush spring tension. 1.5.8 Disconnected lead wire between solenoid and field windings. 1.5.9 Ball bearing sticks.	1.5.1 Check brush spring tension. 1.5.2 Correct on lathe or replace. 1.5.3 Correct by undercutting. 1.5.4 Replace. 1.5.5 Replace. 1.5.6 Replace. 1.5.7 Replace. 1.5.8 Repair or replace lead wire. 1.5.9 Replace bearing.

Table 5-1. Troubleshooting (Continued)

PROBLEM	SOURCE OF PROBLEM	PROBABLE CAUSE	SOLUTION
2. Pinion does not engage with ring gear while starter is running or engine cannot be cranked.	2.1 Battery.	2.1.1 Voltage drop due to discharged battery. 2.1.2 Short-circuited or open between electrodes. 2.1.3 Poor contact condition of battery terminal(s).	2.1.1 Charge battery. 2.1.2 Replace battery. 2.1.3 Clean and retighten.
	2.2 Wiring.	2.2.1 Disconnection between starter switch and solenoid terminal.	2.2.1 Repair or replace wire.
	2.3 Overrunning clutch.	2.3.1 Overrunning clutch malfunction (rollers or compression spring). 2.3.2 Pinion teeth worn out. 2.3.3 Pinion does not run in overrunning direction. 2.3.4 Poor sliding condition of spline teeth. 2.3.5 Reduction gears damaged.	2.3.1 Replace overrunning clutch. 2.3.2 Replace overrunning clutch. 2.3.3 Replace overrunning clutch. 2.3.4 Remove foreign materials, dirt, or replace overrunning clutch. 2.3.5 Replace overrunning clutch and idler gear.
	2.4 Ring gear.	2.4.1 Excessively worn teeth.	2.4.1 Replace ring gear.
3. Starter does not stop running.	3.1 Solenoid.	3.1.1 Return spring worn. 3.1.2 Coil layer shorted. 3.1.3 Contact plate melted and stuck.	3.1.1 Replace solenoid. 3.1.2 Replace solenoid. 3.1.3 Replace solenoid.
	3.2 Starting switch or starter relay.	3.2.1 Unopened contacts. 3.2.2 Poor returning.	3.2.1 Replace starting switch or starter relay. 3.2.2 Replace starting switch or starter relay.

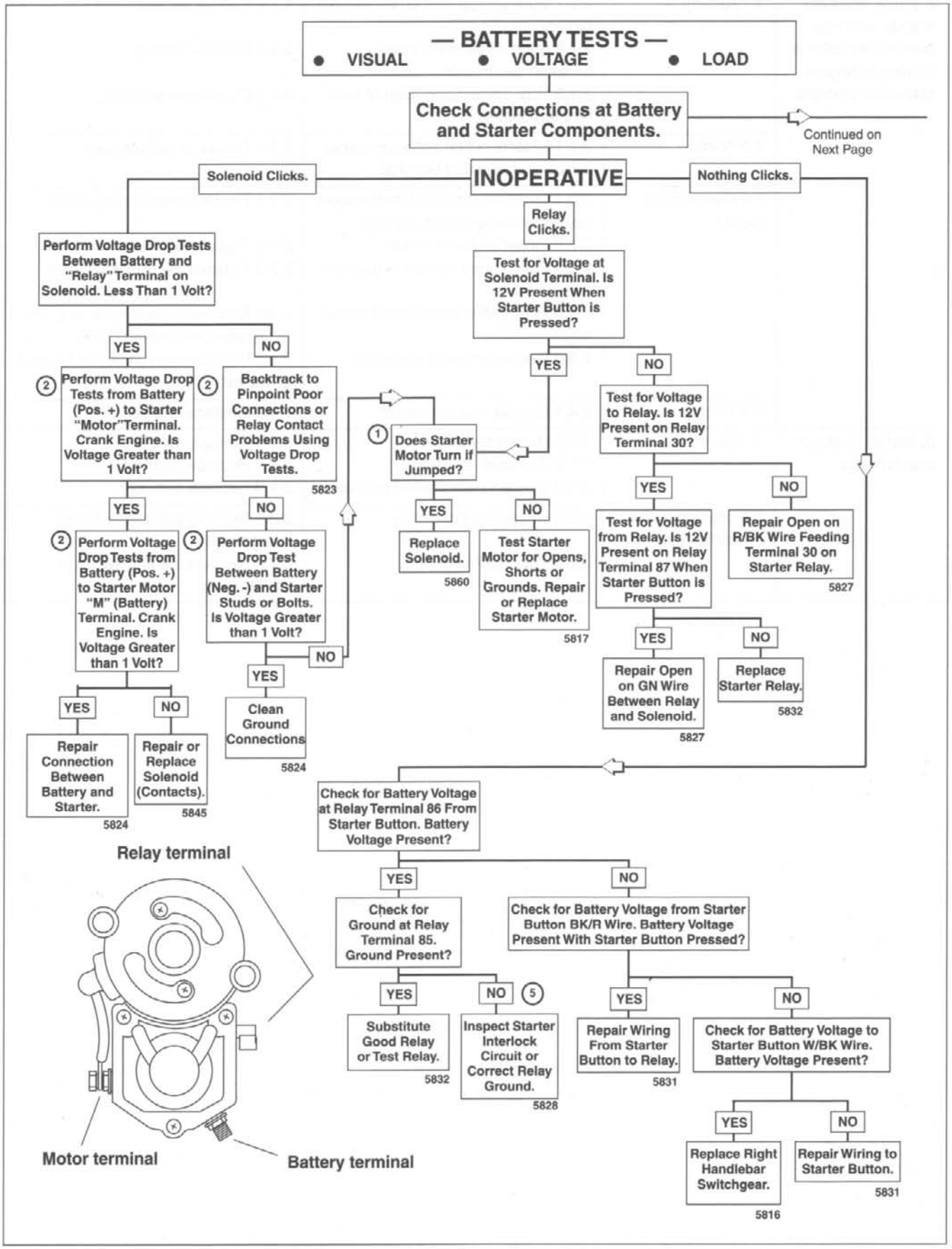
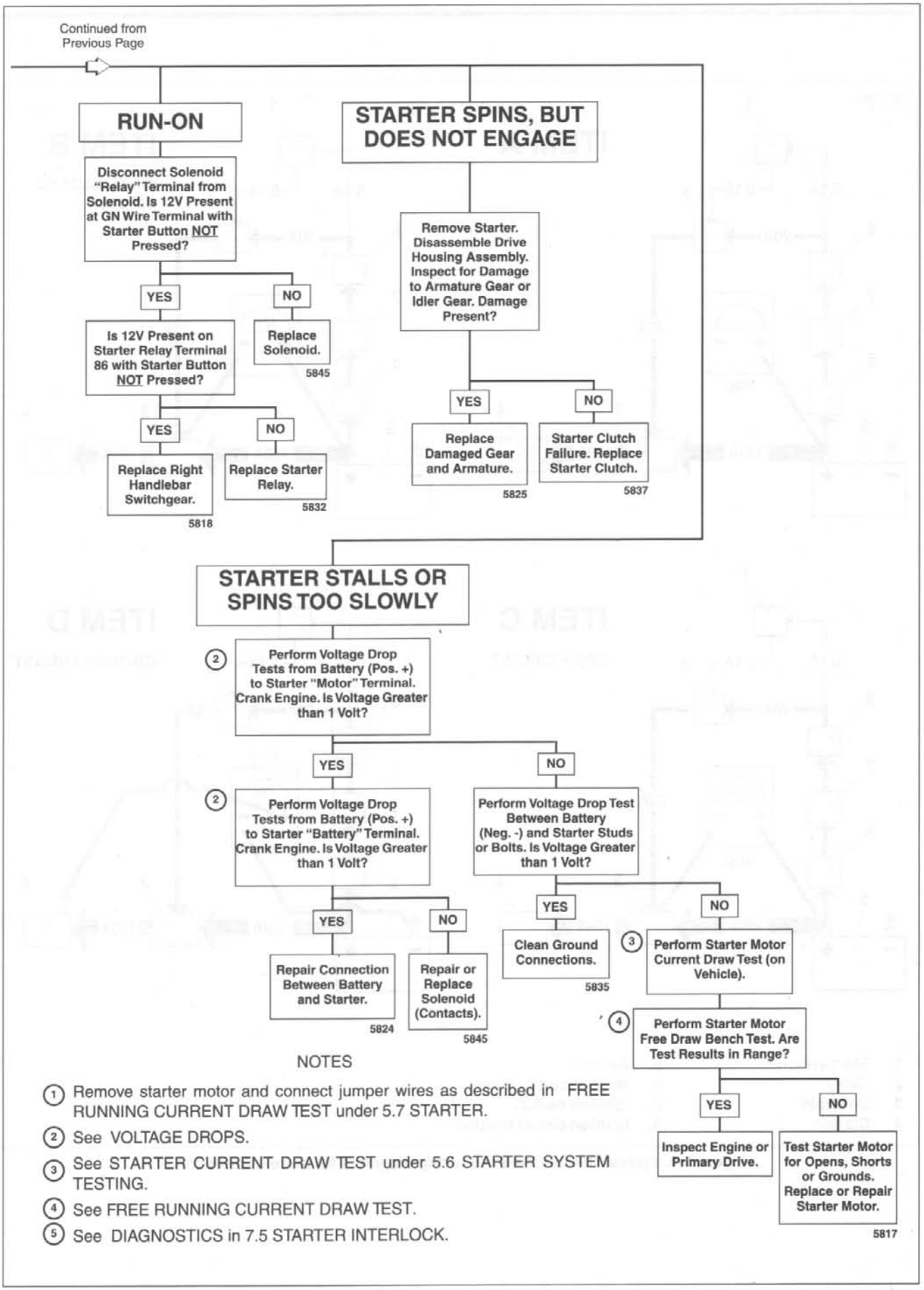


Figure 5-2. Starting System Diagnosis, Part 1



NOTES

1. Remove starter motor and connect jumper wires as described in FREE RUNNING CURRENT DRAW TEST under 5.7 STARTER.
2. See VOLTAGE DROPS.
3. See STARTER CURRENT DRAW TEST under 5.6 STARTER SYSTEM TESTING.
4. See FREE RUNNING CURRENT DRAW TEST.
5. See DIAGNOSTICS in 7.5 STARTER INTERLOCK.

Figure 5-3. Starting System Diagnosis, Part 2

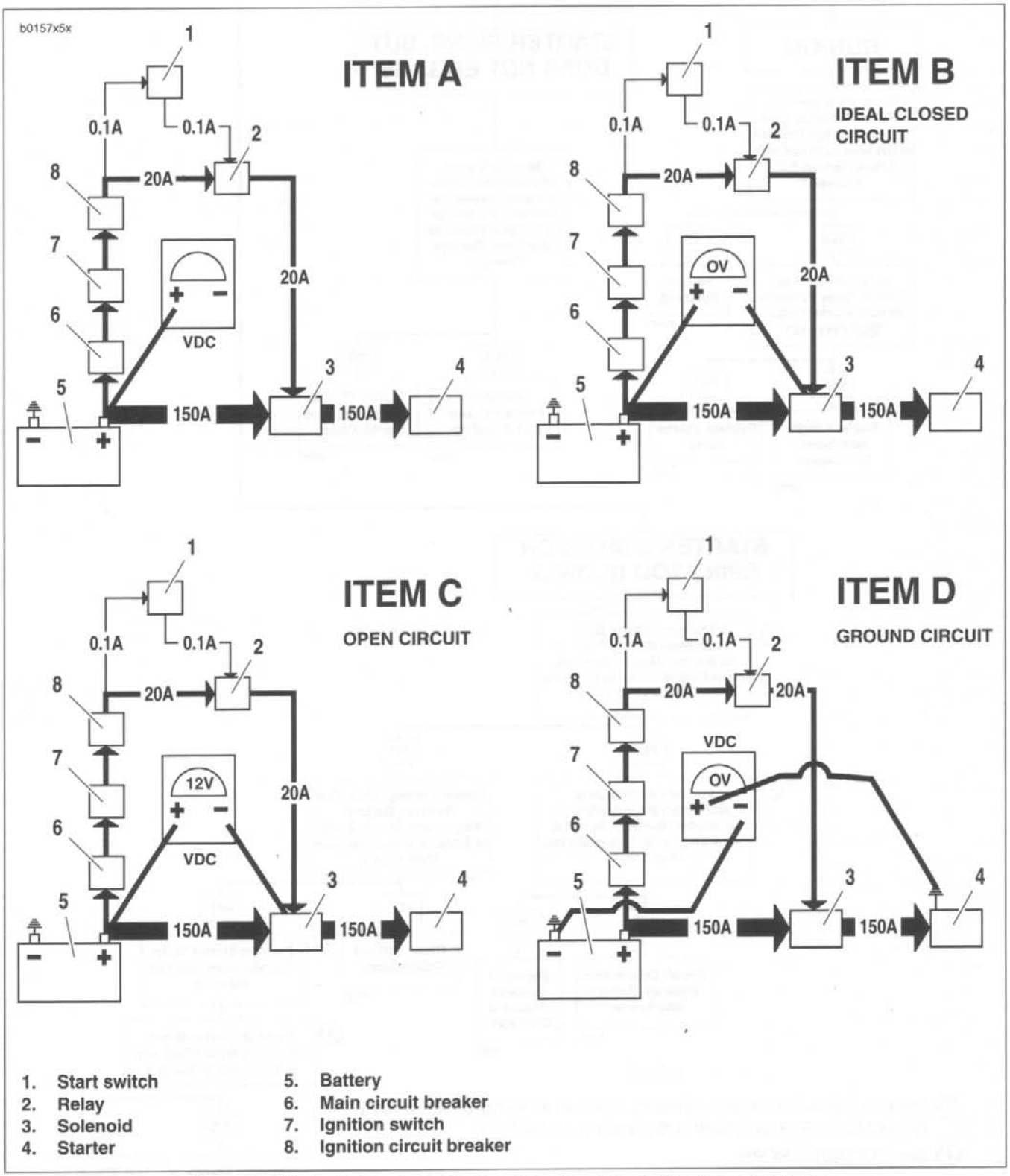


Figure 5-4. Typical Circuity. Refer to wiring diagrams for more information.

GENERAL

The troubleshooting table beginning on page 5-4 contains detailed procedures to solve and correct problems. Follow the 5.3 STARTING SYSTEM DIAGNOSIS diagram to diagnose starting system problems. The VOLTAGE DROPS procedure below will help you to locate poor connections or components with excessive voltage drops.

VOLTAGE DROPS

Check the integrity of all wiring, switches, circuit breakers and connectors between the source and destination.

The voltage drop test measures the difference in potential or the actual voltage dropped between the source and destination.

1. See ITEM A in Figure 5-4. Attach your red meter lead to the most positive part of the circuit, which in this case would be the positive post of the battery (5).
2. See ITEM B in Figure 5-4. Attach the black meter lead to the final destination or component in the circuit (solenoid terminal from relay).
3. Activate the starter and observe the meter reading. The meter will read the voltage dropped or the difference in potential between the source and destination.
4. An ideal circuit's voltage drop would be 0 volts or no voltage dropped, meaning no difference in potential.
5. See ITEM C in Figure 5-4. An open circuit should read 12 volts, displaying all the voltage dropped, and the entire difference in potential displayed on the meter.
6. Typically, a good circuit will drop less than 1 volt.
7. If the voltage drop is greater, back track through the connections until the source of the potential difference is found. The benefit of doing it this way is speed.
   a. Readings aren't as sensitive to real battery voltage.
   b. Readings show the actual voltage dropped, not just the presence of voltage.
   c. This tests the system as it is actually being used. It is more accurate and will display hard to find poor connections.
   d. This approach can be used on lighting circuits, ignition circuits, etc. Start from most positive and go to most negative (the destination or component).
8. See ITEM D in Figure 5-4. The negative or ground circuit can be checked as well.
   a. Place the negative lead on the most negative part of the circuit (or the negative battery post). Remember, there is nothing more negative than the negative post of the battery.
   b. Place the positive lead to the ground you wish to check.
   c. Activate the circuit. This will allow you to read the potential difference or voltage dropped on the negative or ground circuit. This technique is very effective for identifying poor grounds due to powdered paint. Even the slightest connection may cause an ohmmeter to give a good reading. However, when sufficient current is passed through, the resistance caused by the powdered paint will cause a voltage drop or potential difference in the ground circuit.

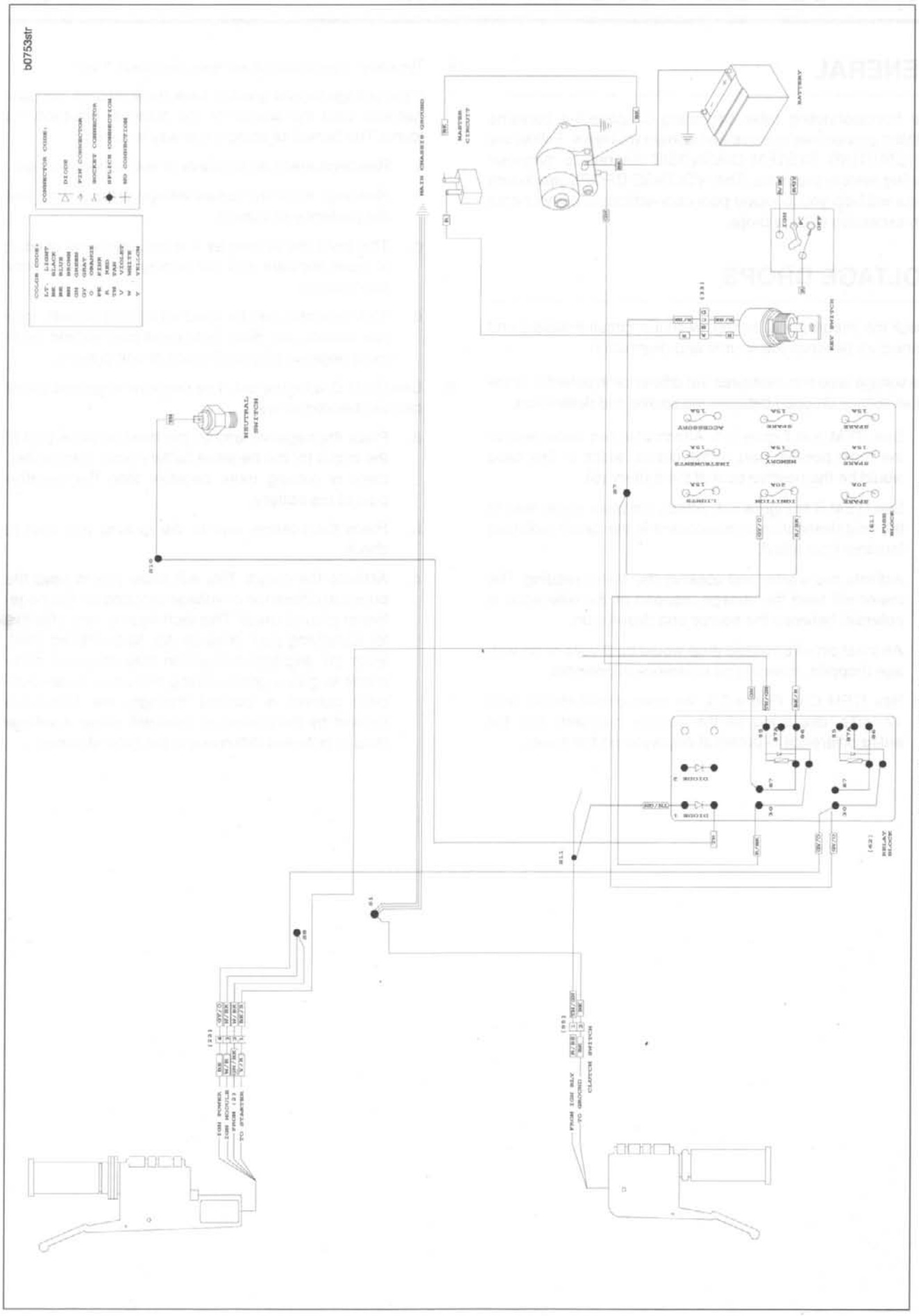


Figure 5-5. Electric Starting System Circuit

"ON-MOTORCYCLE" TESTS

Starter Relay Test

1. See Figure 5-6. Locate starter relay. The relay is attached to the relay block underneath the seat.
2. To test relay, proceed to Step 3. If installing a **new** starter relay, remove old relay. Install **new** relay into relay block.
3. See Figure 5-7. Obtain a 12 volt battery and a continuity tester or ohmmeter.
   a. Pull relay from relay block.
   b. Connect positive battery lead to the 86 terminal.
   c. Connect negative battery lead to the 85 terminal to energize relay.
   d. Check for continuity between the 30 and 87 terminals. A good relay shows continuity (continuity tester lamp "on" or a zero ohm reading on the ohmmeter). A malfunctioning relay will not show continuity and must be replaced.
4. If starter relay is functioning properly, proceed to STARTER CURRENT DRAW TEST.

Starter Current Draw Test

NOTE

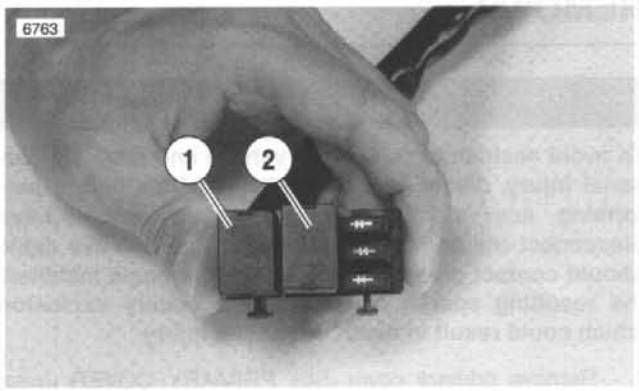
- *Engine temperature should be stable and at room temperature.*
- *Battery should be fully charged.*

See Figure 5-8. Check starter current draw with an induction ammeter before disconnecting battery. Proceed as follows:

1. Verify that transmission is in neutral. Disconnect spark plug wires from spark plug terminals.
2. Clamp induction ammeter over positive battery cable next to starter.
3. With ignition key switch ON, turn engine over by pressing starter switch while taking a reading on the ammeter.

   Disregard initial high current reading which is normal when engine is first turned over.

   a. Typical starter current draw will range between 140-180 amperes.
   b. If starter current draw exceeds 180 amperes, then the problem may be in the starter or starter drive. Remove starter for further tests. See 5.7 STARTER.



1. **Ignition relay**
2. **Starter relay**

Figure 5-6. Starter Relay Block

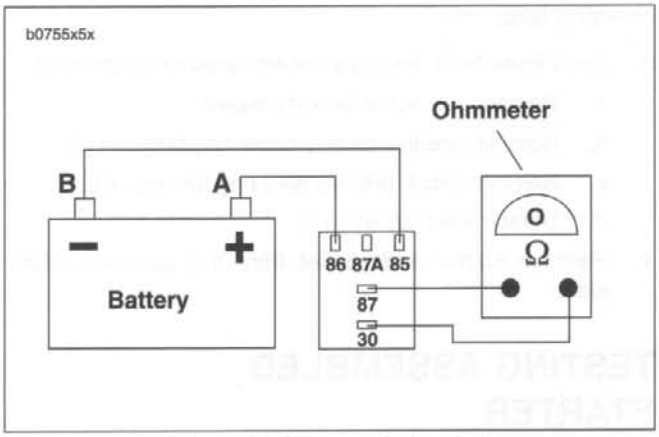


Figure 5-7. Starter Relay Test

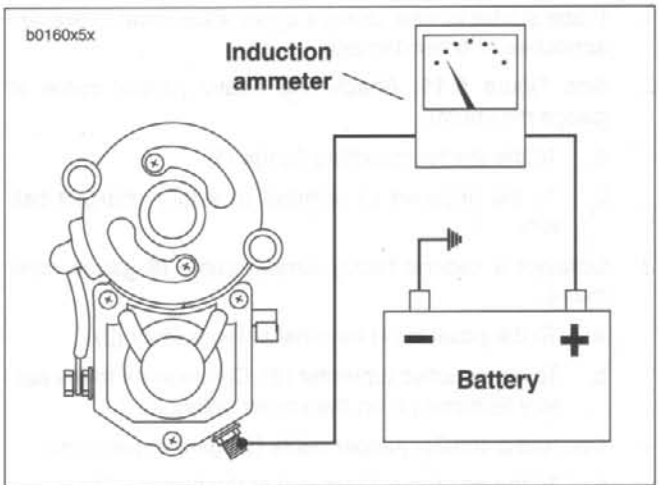


Figure 5-8. Starter Draw Test

REMOVAL

⚠WARNING

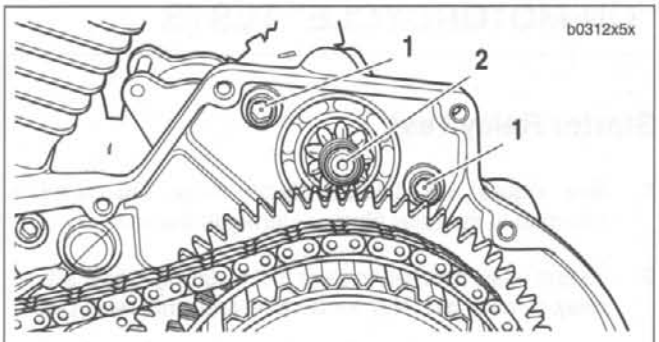
To avoid accidental start-up of vehicle and possible personal injury, disconnect the battery cables before performing any of the following procedures. Always disconnect the negative cable first. If the positive cable should contact ground with the negative cable installed, the resulting sparks could cause a battery explosion which could result in death or serious injury.

1. Remove primary cover. See PRIMARY COVER under 6.2 PRIMARY CHAIN.
2. See Figure 5-9. Remove both starter mounting bolts and washers (1).

NOTE

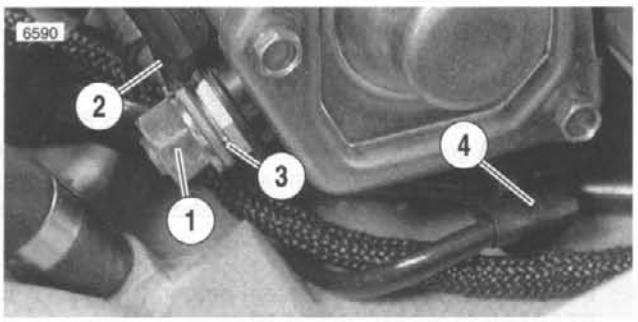
A ball hex driver may be required to gain access to the starter mounting bolts.

3. See Figure 5-10. Remove nut with washer (1) (metric).
   a. Remove protective boot if present.
   b. Remove positive battery cable ring terminal (2).
   c. Remove circuit breaker wire ring terminal (3).
   d. Detach solenoid wire (4).
4. Remove starter and gasket from the gearcase cover side.



1. **Mounting bolts and washers**
2. **Starter**

Figure 5-9. Starter Mounting



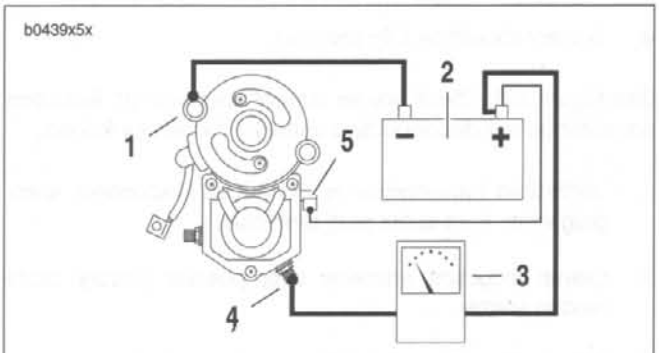
1. **Nut with washer (metric)**
2. **Positive battery cable ring terminal**
3. **Circuit breaker wire ring terminal**
4. **Solenoid wire**

Figure 5-10. Starter Wires (Protective Boot Not Shown)

TESTING ASSEMBLED STARTER

Free Running Current Draw Test

1. Place starter in vise, using a clean shop towel to prevent scratches or other damage.
2. See Figure 5-11. Attach one heavy jumper cable (6 gauge minimum).
   a. To the starter mounting flange (1).
   b. To the negative (-) terminal of a fully charged battery.
3. Connect a second heavy jumper cable (6 gauge minimum).
   a. To the positive (+) terminal of the battery (2).
   b. To an inductive ammeter (3). Continue on to the battery terminal (4) on the starter solenoid.
4. Connect a smaller jumper cable (14 gauge minimum).
   a. To the positive (+) terminal of the battery (2).
   b. To the solenoid relay terminal (5).
5. Check ammeter reading.
   a. Ammeter should show 90 amps maximum.
   b. If reading is higher, disassemble starter for inspection. See 5.7 STARTER.



1. **Mounting flange**
2. **Battery**
3. **Induction ammeter**
4. **Battery terminal**
5. **Relay terminal**

Figure 5-11. Free Running Current Draw Test

   c. If starter current draw on vehicle was over 200 amps and this test was within specification, there may be a problem with engine or primary drive.

Starter Solenoid

NOTE

Do not disassemble solenoid. Before testing, disconnect field wire from motor terminal as shown in Figure 5-12.

CAUTION

Each test should be performed for only 3-5 seconds to prevent damage to solenoid.

NOTE

The solenoid Pull-in, Hold-in, and Return tests must be performed together in one continuous operation. Conduct all three tests one after the other in the sequence given without interruption.

Solenoid Pull-in Test

1. See Figure 5-12. Using a 12 volt battery, connect three separate test leads as follows:
   a. Solenoid housing to negative battery post.
   b. Solenoid motor terminal to negative battery post.
   c. Solenoid relay terminal to positive battery post.
2. Observe starter pinion.
   a. If starter pinion pulls in strongly, solenoid is working properly.
   b. If starter pinion does not pull in, replace the solenoid.

Solenoid Hold-in Test

1. See Figure 5-13. With test leads still connected in the manner specified in the previous SOLENOID PULL-IN TEST, **disconnect solenoid motor terminal/battery negative test lead (B) at negative battery post only; reconnect loose end of this test lead to positive battery post instead.**
2. Observe starter pinion.
   a. If starter pinion remains in pull-in position, solenoid is working properly.
   b. If starter pinion does not remain in pull-in position, replace the solenoid.

Solenoid Return Test

1. See Figure 5-14. With test leads still connected in the manner specified at the end of the previous SOLENOID HOLD-IN TEST, **disconnect solenoid relay terminal/positive battery post test lead (C) at either end.**
2. Observe starter pinion.
   a. If starter pinion returns to its original position, solenoid is working properly.
   b. If starter pinion does not return to its original position, replace the solenoid.

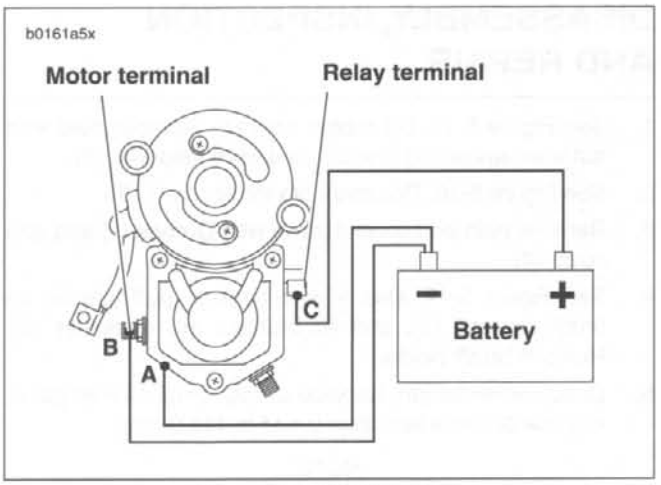


Figure 5-12. Pull-In Test

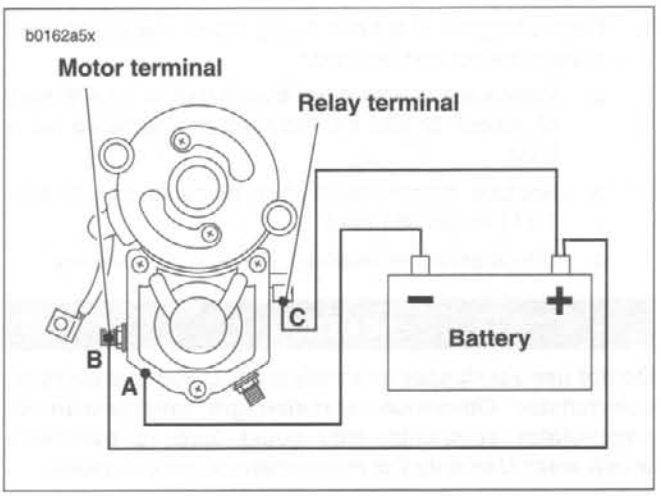


Figure 5-13. Hold-In Test

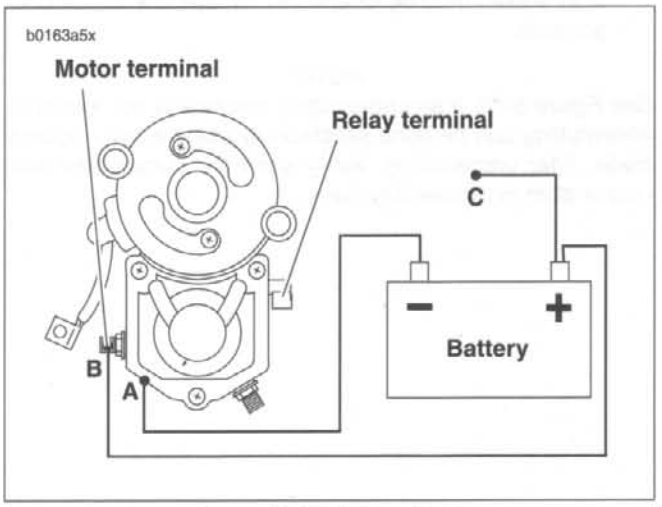


Figure 5-14. Return Test

DISASSEMBLY, INSPECTION AND REPAIR

1. See Figure 5-15. Lift rubber boot (1). Remove field wire nut with washer (2) (metric) to detach field wire (3).
2. See Figure 5-16. Remove both thru-bolts (1, 3).
3. Remove both end cover screws with O-rings (2) and end cover (4).
4. See Figure 5-17. Use a wire hook to pull upward on brush springs (3), and lift brushes out of holder (2). Remove brush holder.
5. Check brush length. Replace all four brushes if length of any one brush is less than 0.433 in. (11.0 mm).

NOTE

Brushes not available separately. Purchase a ***new*** *field frame (1) and brush holder (2) to replace brushes.*

6. Remove armature (4) and field frame (1).
7. Place armature in lathe or truing stand and check commutator runout and diameter.
   a. Commutators with more than 0.016 in. (0.406 mm) of runout should be replaced or machined on a lathe.
   b. Replace commutators when diameter is less than 1.141 in. (28.981 mm)
   c. Check armature bearings. Replace if necessary.

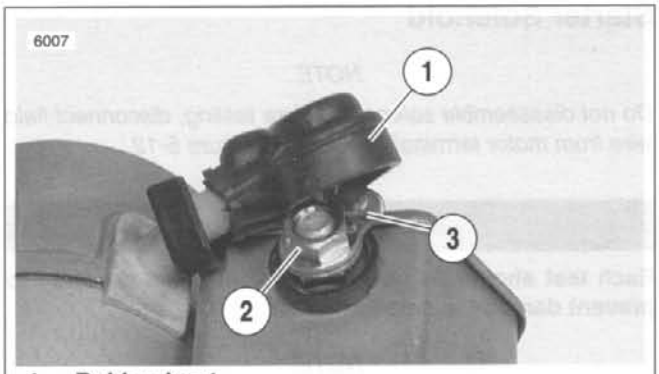
CAUTION

Do not use sandpaper or emery cloth to remove burrs on commutator. Otherwise, abrasive grit may remain on commutator segments; this could lead to excessive brush wear. Use only the recommended crocus cloth.

8. Check depth of mica on commutator. If undercut is less than 0.008 in. (0.203 mm), use an undercutting machine to undercut the mica to 1/32 in. (0.794 mm) deep. The slots should then be cleaned to remove any dirt or copper dust.

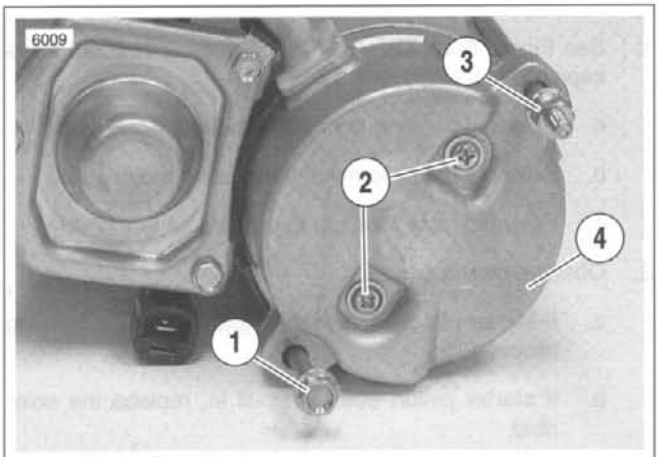
NOTE

See Figure 5-18. If an undercutting machine is not available, undercutting can be done satisfactorily using a thin hacksaw blade. After undercutting, lightly sand the commutator with crocus cloth to remove any burrs.



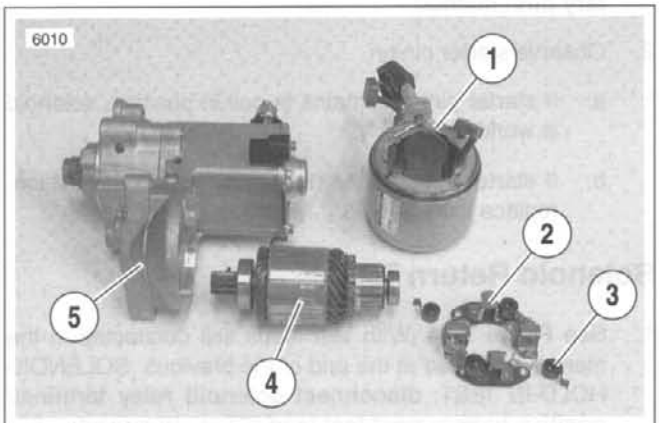
1. **Rubber boot**
2. **Field wire nut with washer (metric)**
3. **Field wire**

Figure 5-15. Field Wire



1. **Lower thru-bolt**
2. **Screw w/o-ring (2)**
3. **Upper thru-bolt**
4. **End cover**

Figure 5-16. Removing the Thru-Bolts



1. **Field frame**
2. **Brush holder**
3. **Brush spring (4)**
4. **Armature**
5. **Solenoid housing**

Figure 5-17. Starter Components

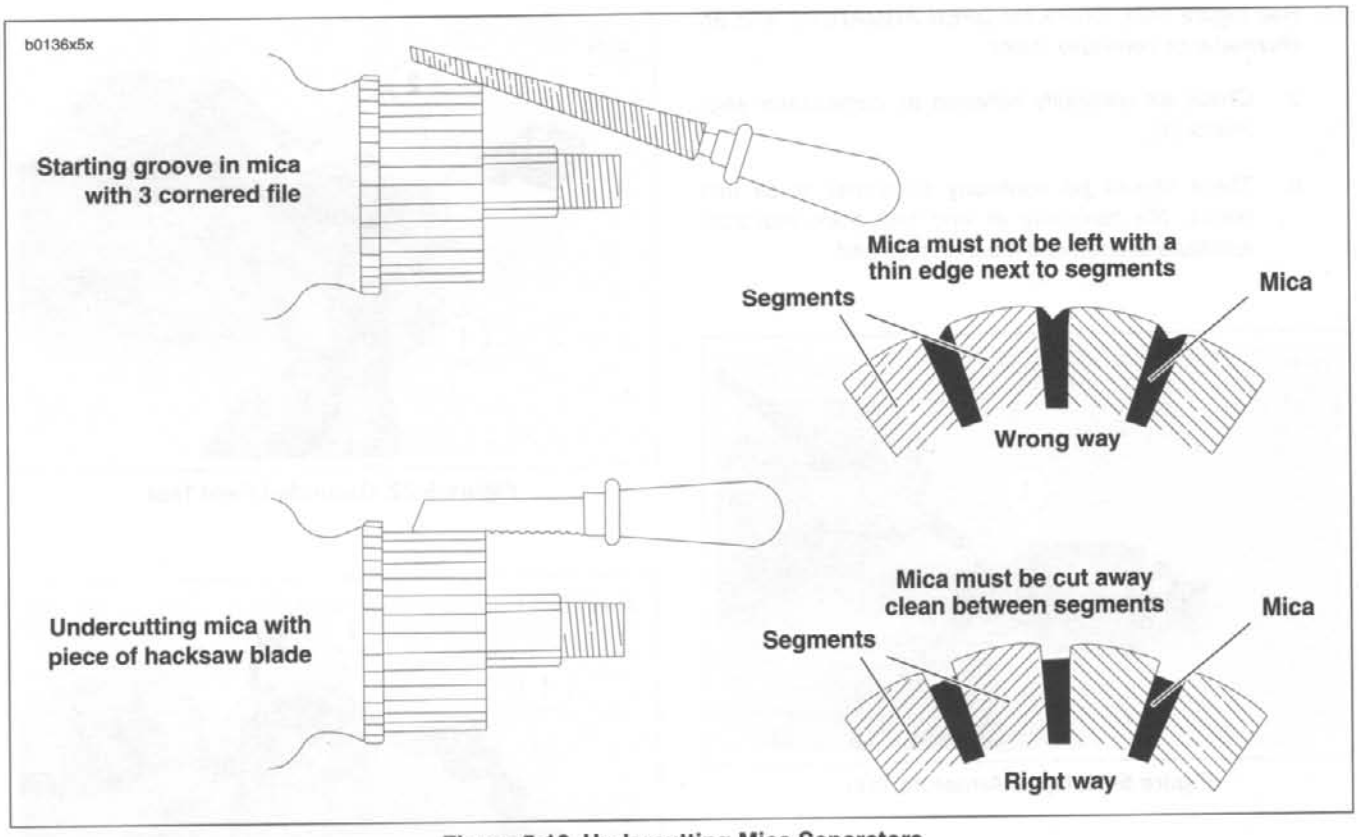


Figure 5-18. Undercutting Mica Separators

9. See Figure 5-19. Check for SHORTED ARMATURE with a growler.
   a. Place armature on growler (1).
   b. Hold a thin steel strip (2) (hacksaw blade) against armature core and slowly turn armature.
   c. A shorted armature will cause the steel strip to vibrate and be attracted to the core. Replace shorted armatures.

10. See Figure 5-20. Check for a GROUNDED ARMATURE with an ohmmeter or continuity tester.
    a. Touch one probe to any commutator segment (1).
    b. Touch the other probe to the armature core (2).
    c. There should be no continuity (infinite ohms). If there is continuity, then the armature is grounded. Replace grounded armatures.

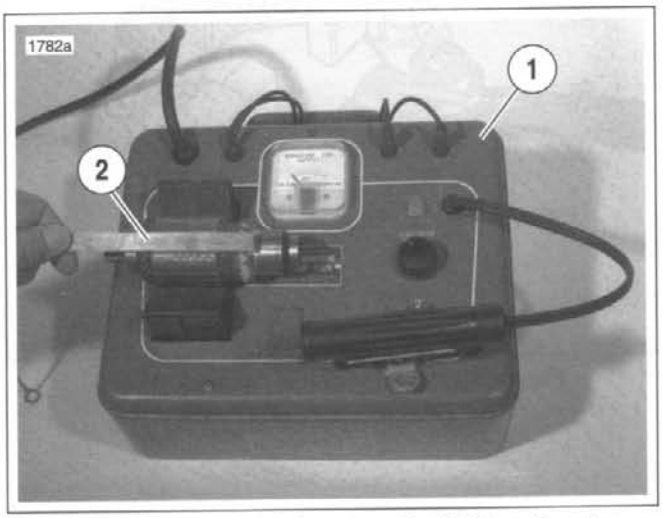


Figure 5-19. Shorted Armature Test Using Growler

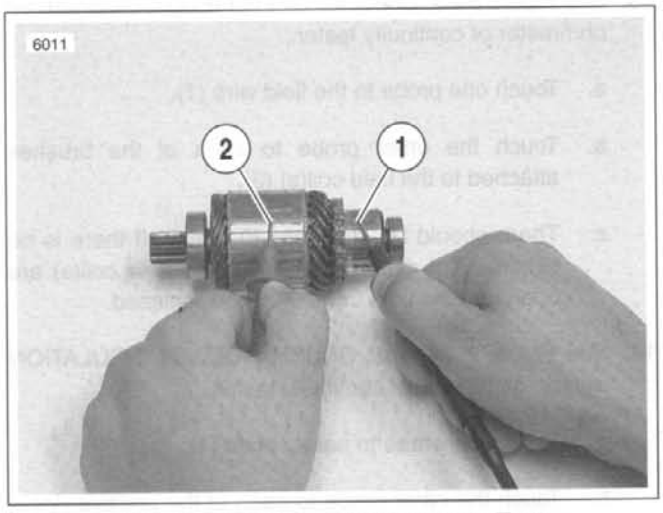


Figure 5-20. Grounded Armature Test

11. See Figure 5-21. Check for OPEN ARMATURE with an ohmmeter or continuity tester.

    a. Check for continuity between all commutator segments (1).

    b. There should be continuity (0 ohms) at all test points. No continuity at any test point indicates armature is open and must be replaced.

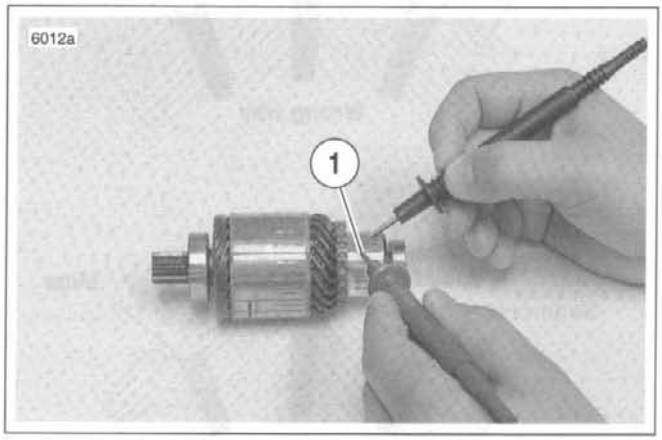


Figure 5-21. Open Armature Test

12. See Figure 5-22. Check for GROUNDED FIELD COIL with an ohmmeter or continuity tester.

    a. Touch one probe to the frame (1).

    b. Touch the other probe to each of the brushes (2) attached to the field coil.

    c. There should be no continuity (infinite ohms). If there is any continuity at either brush, then the field coil(s) are grounded and the field frame must be replaced.

13. See Figure 5-23. Check for OPEN FIELD COILS with an ohmmeter or continuity tester.

    a. Touch one probe to the field wire (1).

    b. Touch the other probe to each of the brushes attached to the field coil(s) (2).

    c. There should be continuity (0 ohms). If there is no continuity at either brush, then the field coil(s) are open and the field frame must be replaced.

14. See Figure 5-24. Test BRUSH HOLDER INSULATION with an ohmmeter or continuity tester.

    a. Touch one probe to holder plate (1).

    b. Touch the other probe to each of the positive (insulated) brush holders (2).

    c. There should be no continuity (infinite ohms). If there is continuity at either brush holder, replace the brush holder assembly.

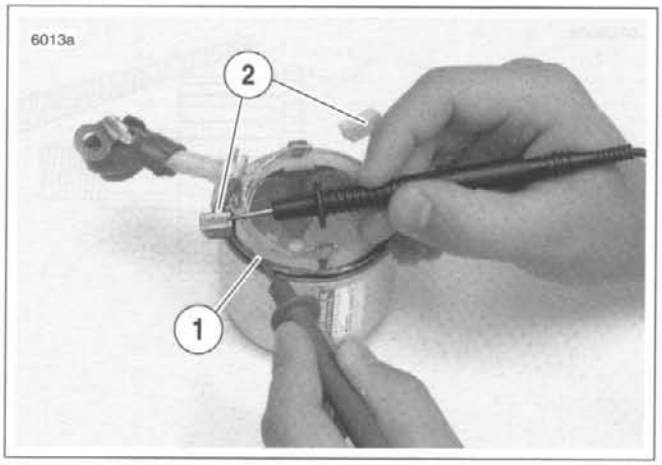


Figure 5-22. Grounded Field Test

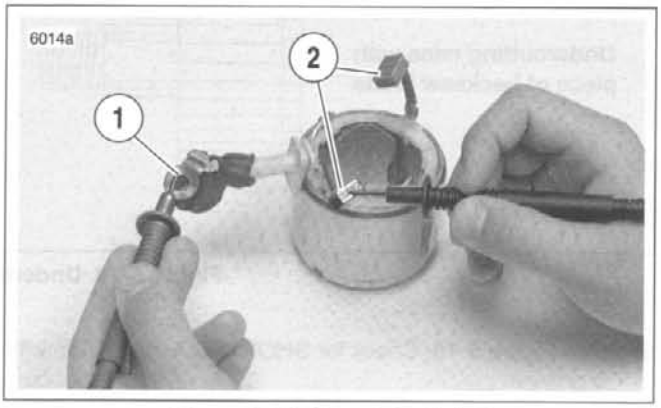


Figure 5-23. Open Field Test

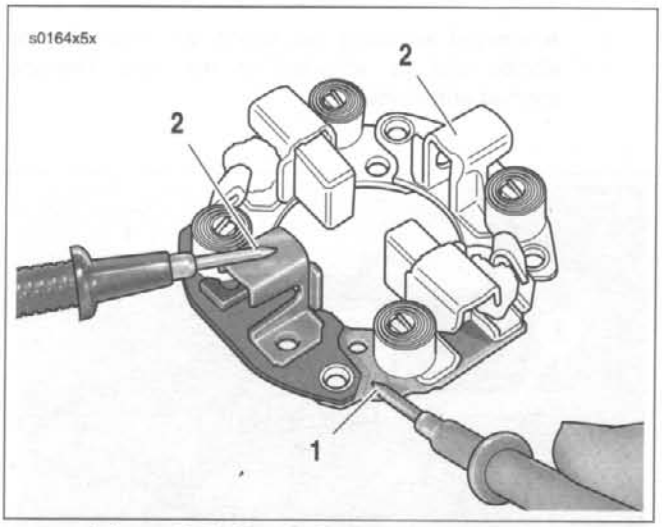


Figure 5-24. Brush Holder Insulation Test

15. See Figure 5-25. Remove two drive housing mounting screws (6). Remove drive housing (5) from solenoid housing.

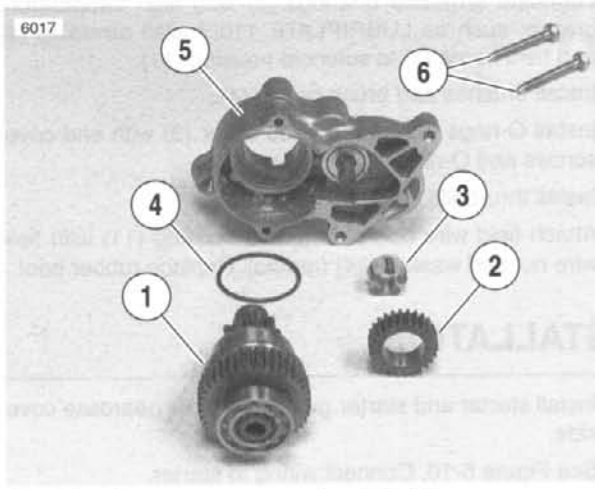
16. Remove drive (1), idler gear (2), idler gear bearing (3), and O-ring (4) from drive housing (O-ring is located in drive housing groove).

ASSEMBLY

1. See Figure 5-25. Clean, inspect and lubricate drive assembly components. Lubricate parts with high temperature grease, such as LUBRIPLATE 110.

2. See Figure 5-26. When installing drive assembly components, open end of idler bearing cage (15) faces toward solenoid.

3. When installing drive housing (10) to solenoid housing (11), use **new** O-ring (16). Be sure to install return spring (17) and ball (18).



1. Drive
2. Idler gear
3. Idler gear bearing
4. O-ring
5. Drive housing
6. Screws

Figure 5-25. Starter Drive Assembly

1. Thru-bolt (2)
2. End cover screw and o-ring (2)
3. End cover
4. Brush holder
5. Brush spring (4)
6. Armature
7. Field frame
8. Armature bearing (2)
9. Drive housing mounting bolt
10. Drive housing
11. Solenoid housing
12. Drive assembly/ overrunning clutch
13. Idler gear
14. Idler gear roller (5)
15. Idler gear bearing cage
16. O-ring
17. Return spring
18. Ball
19. Gasket
20. Washer (2)
21. Mounting bolt (2)
22. Field wire
23. O-ring (2)
24. Field wire nut with washer (metric)

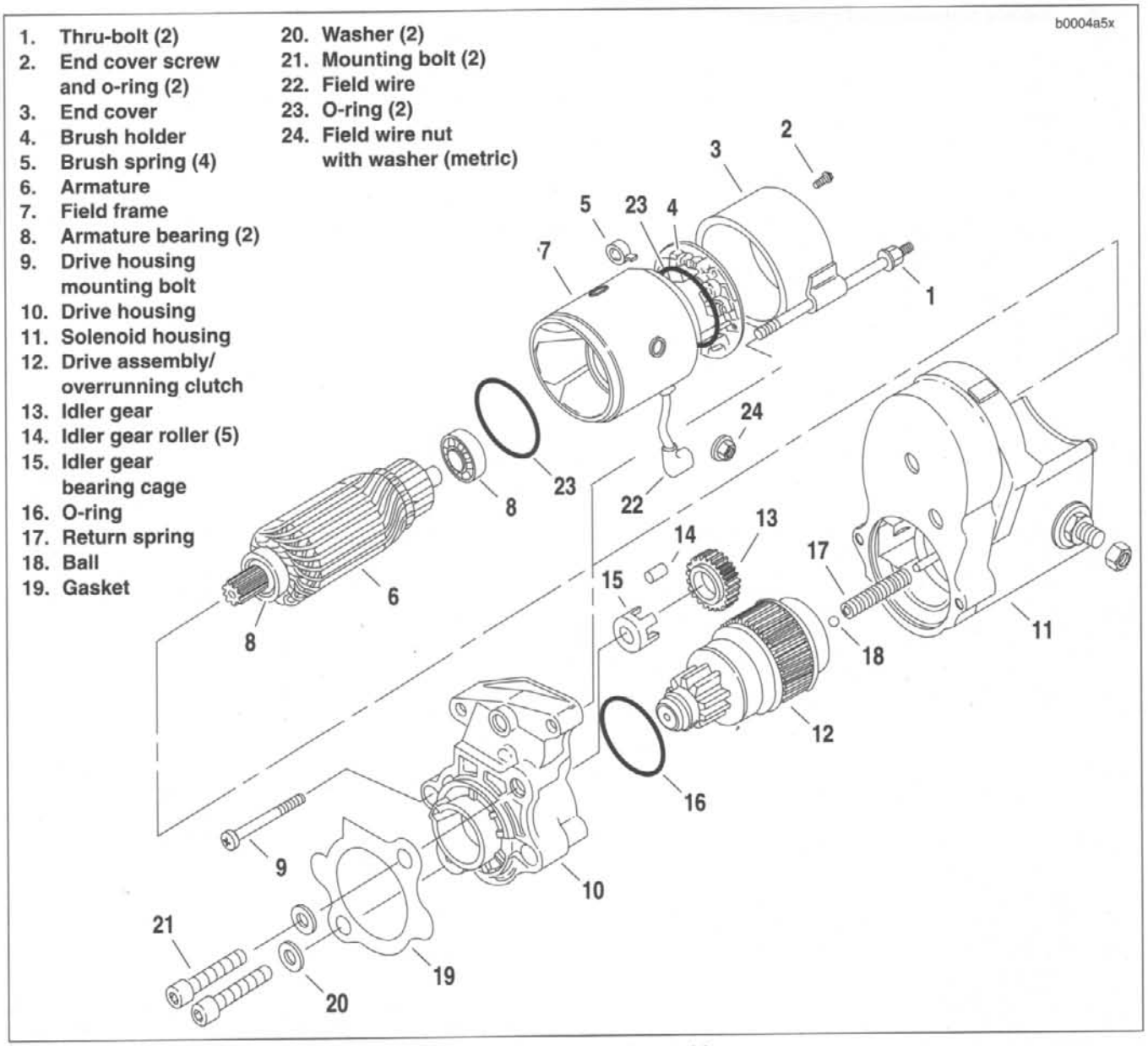


Figure 5-26. Starter Assembly

4. Lubricate armature bearings (8) with high temperature grease, such as LUBRIPLATE 110. Install armature (6) and field frame (7) to solenoid housing (11).
5. Install brushes and brush holder (4).
6. Install O-rings (23). Attach end cover (3) with end cover screws and O-rings (2).
7. Install thru-bolts (1).
8. Attach field wire (22) to solenoid housing (11) with field wire nut and washer (24) (metric). Replace rubber boot.

INSTALLATION

1. Install starter and starter gasket from the gearcase cover side.
2. See Figure 5-10. Connect wiring to starter.
   a. Connect solenoid wire (4).
   b. Attach circuit breaker wire ring terminal (3).
   c. Attach positive battery cable ring terminal (2).
   d. Install nut with washer (1) (metric). Tighten to 60-85 **in-lbs** (6.8-9.6 Nm).
   e. Replace protective boot if present.
3. See Figure 5-9. Install both starter mounting bolts and washers. Tighten to 13-20 ft-lbs (17.6-27.1 Nm).
4. Install primary cover. See PRIMARY COVER under 6.2 PRIMARY CHAIN.
5. Fill transmission to proper level with fresh lubricant. See 1.12 CLUTCH.

⚠WARNING

Always connect positive battery cable first. If the positive cable should contact ground with the negative cable installed, the resulting sparks could cause a battery explosion which could result in death or serious injury.

6. Connect battery cables, positive cable first.

   1999 Models: Tighten terminal hardware (metric) to 40 **in-lbs** (4.5 Nm).

   2000 Models: TIghten terminal hardware to 60-85 **in-lbs** (6.8-9.6 Nm).

STARTER SOLENOID 5.8

GENERAL

CAUTION

See Figure 5-27. Do not tighten nut (7) without removing items 1-5. Movement will cause damage to the contact.

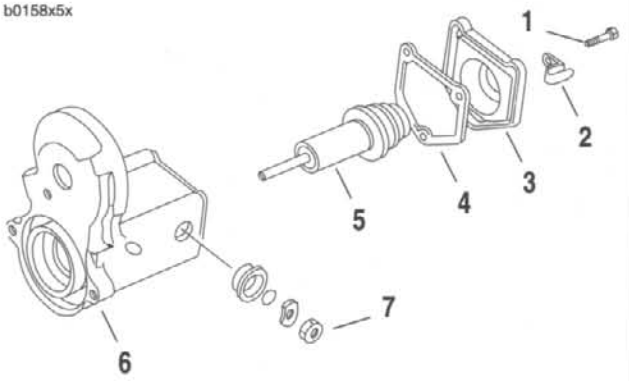
The starter solenoid is a switch that is designed to open and close the starting circuit electromagnetically. The switch consists of contacts and a winding around a hollow cylinder containing a movable plunger.

DISASSEMBLY

1. See Figure 5-27. Remove screws (1) and clip (2).
2. Remove cover (3) and gasket (4). Discard gasket.
3. Remove plunger (5) from solenoid housing (6).

ASSEMBLY

1. See Figure 5-27. Replace wire connection hardware as necessary.
2. Install plunger (5) in solenoid housing (6).
3. Install **new** gasket (4) onto cover (3).
4. Position cover with gasket onto solenoid housing. Install clip (2) and screws (1).



1. **Screw (3)**
2. **Clip**
3. **Cover**
4. **Gasket**
5. **Plunger**
6. **Solenoid housing**
7. **Nut**

Figure 5-27. Starter Solenoid